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(54) **Storage Bin Activator Device and Method of Restoring Bulk Material Free Flow**

(57) A storage bin activator device 10 comprises a compressed gas storage tank 22 which is connected to the storage bin 40 via an electrically operated valve 26 and a pipe and elbow assembly 28. The valve is operated by an electrical programmer which produces electrical signals in the millisecond range, so as to direct a precise pattern of multiple instantaneous energy bursts of impact, aeration and sonic stimulation directly into bulk material within the bin 40 to free the material for discharge.

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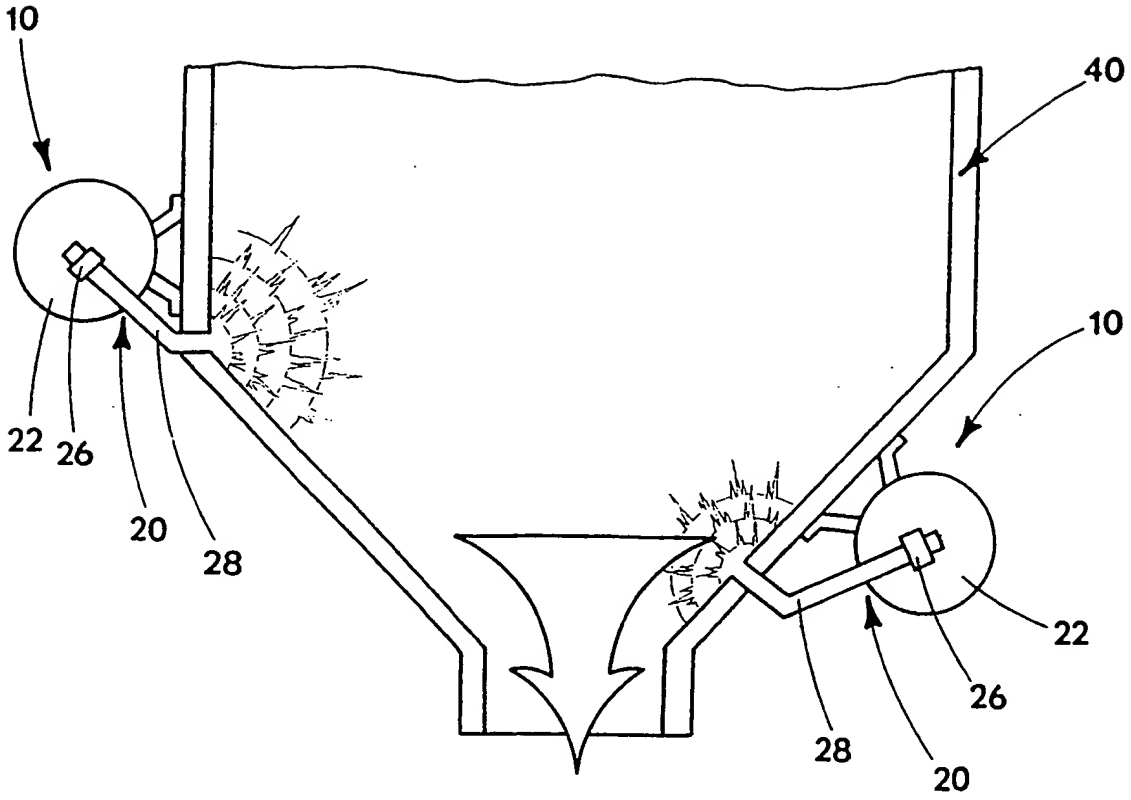

FIG. 1

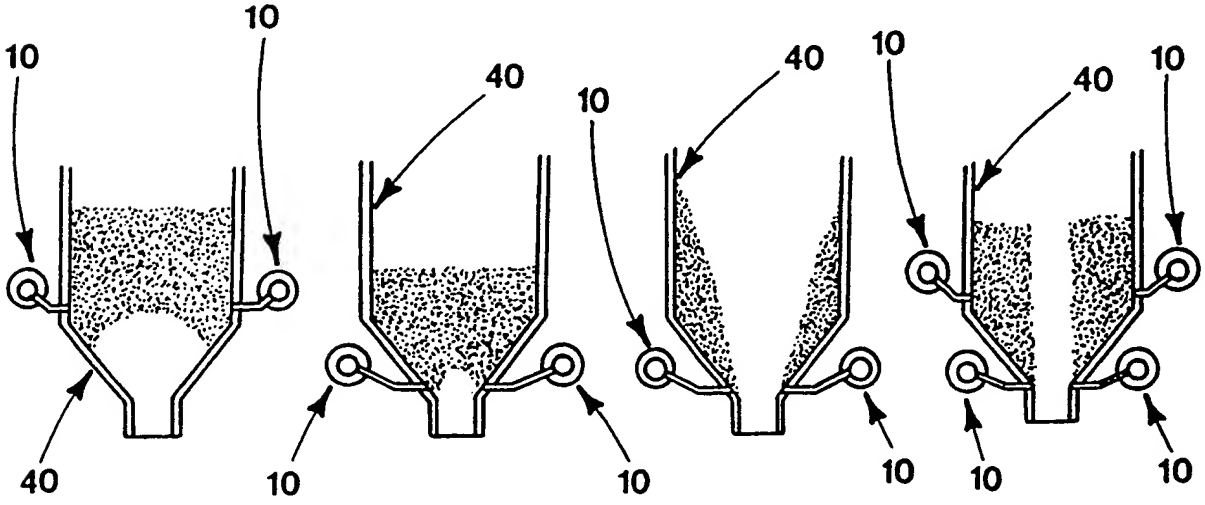

FIG. 1a FIG. 1b FIG. 1c FIG. 1d

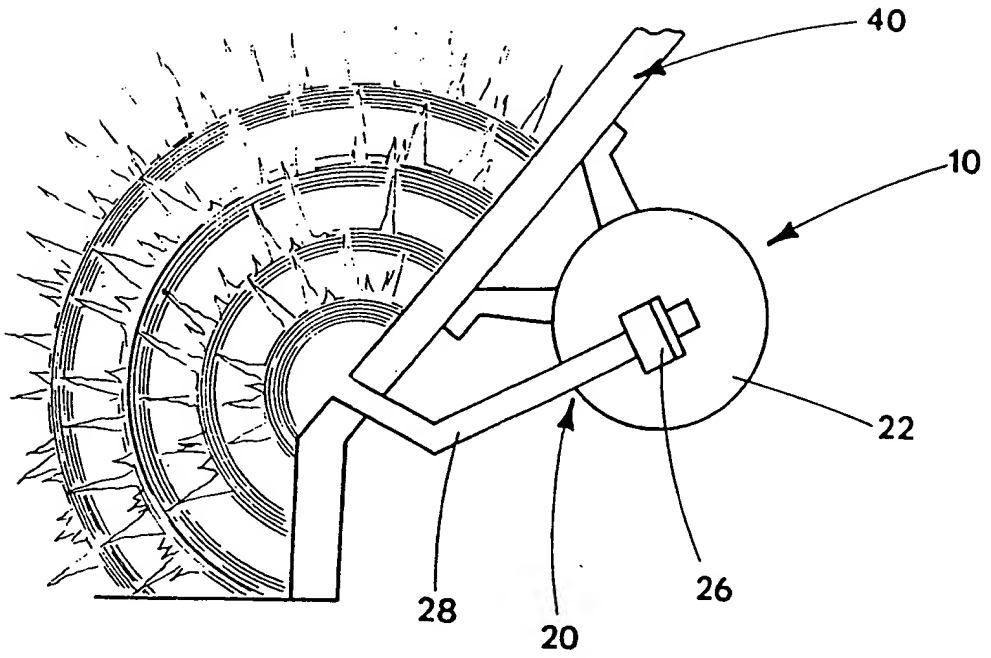

FIG. 2

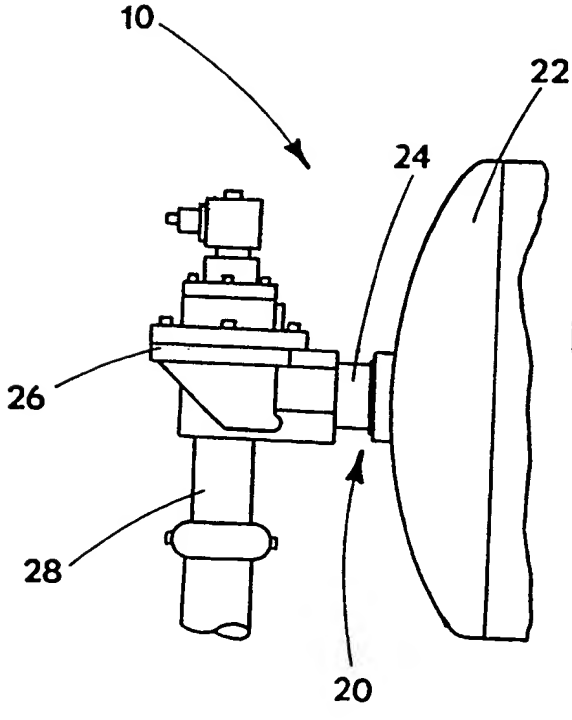

FIG. 3

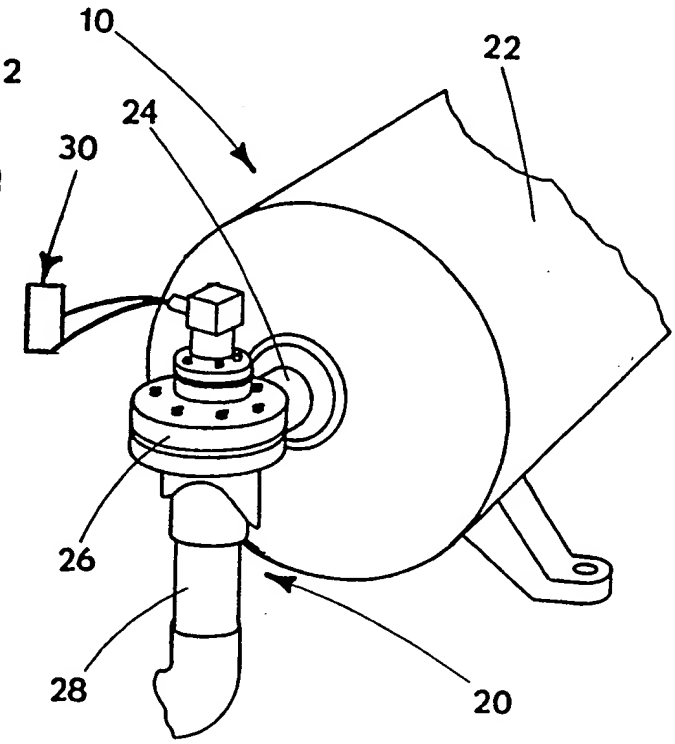

FIG. 4

SPECIFICATION
Storage Bin Activator Device

This invention relates to a storage bin activator device that directs a precise pattern of multiple instantaneous energy bursts of impact, aeration and sonic stimulation directly into bulk material within the storage bin to free same for discharge. The invention also concerns a method of restoring free flow or removing disruptive material in a storage or other containment vessel.

It is well known that storage bins, hoppers and other storage vessels for bulk granular material have flow problems in the gravity feeding of such materials through a discharge opening at the lower end of such storage vessels. Common flow problems include, for example, material arching, bridging and clinging which can be caused by bin size and design, material flow characteristics, flow patterns (mass or funnel), temperature, humidity and other environmental and physical conditions. Other flow problems include the accumulation of materials in recessed channels, seal areas or surfaces and the like which, by their presence, cause interference with normal operation.

Various types of apparatus and methods have been employed in the past, including vibrator and other heavy impact devices which operate on the walls of the storage containers as well as devices which direct compressed air into the storage chamber in an attempt to break up the material for easy flow. It has been found that devices of the last mentioned type are not only more effective, but also reduce wear and tear on hopper walls and other equipment, thus resulting in longer equipment life, less down time and reduced maintenance. Examples of such prior art shown in U.S. Patent Nos. 2,171,398; 3,249,263; 3,861,753; and 4,067,623.

The present invention is directed to devices of the last mentioned type, except that as compared with known prior art devices of this type, the present invention through adjustable multiple instantaneous bursts (usually less than one second) clears materials lodged in storage containers to induce free flow of the material through the discharge opening. All other prior art devices utilize compressed air over much longer periods or single blasts; however, for the reasons which will be discussed herein, such devices are not as effective as the multiple instantaneous energy burst concept of the present invention.

According to the invention, in one aspect thereof, there is provided a material activator device to restore the free flow of material or remove disruptive materials from a containment vessel, comprising means for introducing multiple instantaneous energy bursts of impact, aeration and sonic stimulation directly into the material to dislodge or induce free flow thereof from the containment vess l.

According to another aspect, the invention provides a method of restoring free flow or removing disruptiv materials from a containment vessel, comprising the steps of introducing multiple instantaneous energy bursts of impact, aeration and sonic stimulation acting directly into the material to dislodge or induce free flow thereof from the containment vessel.

Further, the present invention utilizes the multiple instananeous energy bursts for the removal of disruptive materials from unwanted areas which cause interference with normal operation.

In order that the invention may be readily understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a fragmentary schematic side elevational view, partly in section, of a storage bin on which are mounted two storage bin activator devices which are constructed in accordance with the present invention;

Figure 1a is a reduced in size fragmentary schematic side elevational view, partly in section, showing one preferred mounting of two storage bin activator devices on a storage bin to prevent arching flow problems;

Figure 1b is a reduced in size fragmentary schematic side elevational view, partly in section, showing one preferred mounting of two storage bin activator devices on a storage bin to prevent bridging flow problems;

Figure 1c is a reduced in size fragmentary schematic side elevational view, partly in section, showing one preferred mounting of two storage bin activator devices on a storage bin to prevent clinging flow problems;

Figure 1d is a reduced in size fragmentary schematic side elevational view partly in section, showing one preferred mounting of a plurality of storage bin activator devices on a storage bin to prevent piping or rathole problems;

Figure 2 is an enlarged in size fragmentary schematic side elevational view, partly in section, showing one preferred manner of mounting each storage bin activator device on a storage bin, and further showing the theoritical multiple instantaneous energy burst pattern (adjustable) obtained from each injector;

Figure 3 is a fragmentary side elevational view of the injector means comprising one of the components of the storage bin activator device of the present invention; and

Figure 4 is a fragmentary perspective view of the injector and programmer means comprising the storage bin activator device of the present invention.

In accordance with the present invention, bulk granular materials that arch, bridge, cling or rathole in storage, transportation, or surge vessels, including recesses thereof, are activated into freely moving particles by responding to a programmed energy release acting directly into the bulk material in the form of multiple instantaneous energy bursts as pulses of compressed gas, i.e., air. The energy bursts or pulses are preferably released at th desired field adjustable rate or frequency to which the bulk material is most responsive in order to achieve

maximum stimulation. As a result, bulk material free flow is immediately restored to permit escape from the discharge opening of a storage bin or vessel. The multiple instantaneous energy burst pattern also effectively removes disruptive materials from recessed channels, seal areas or surfaces that interfere with normal operation.

Referring more particularly to the drawings, it will be seen that a storage bin activator device 10 embodying the present invention includes two basic components, namely an injector means 20 and a programmer means 30. The injector means 20 includes a compressed gas storage tank 22 which is connected through nipple and pipe assemblies 24 to an electrically operated valve 26 which is mounted at one end of the compressed gas storage tank 22. The electrically operated valve 26 connects the compressed gas storage tank 22 to the storage bin or vessel 40 by way of the pin union and elbow assemblies 28 which have the free end thereof inserted into the storage bin or vessel 40, as shown in Figures 1—2. It will be noted that the arrangement of the compressed gas storage tank 22, electrically operated valve 26 and other aforementioned components of the injector means 20 permits close mounting thereof relative to the storage bin or vessel 40 in order to allow the multiple energy bursts from the injector means 20 to effectively act within the short allotted time on the bulk material with minimum system losses.

The electrically operated valve 26, i.e., solenoid controlled or the like, is designed to operate at the speeds established by the programmer means 30.

As discussed below, the programmer means 30 is designed to emit electrical signals in the approximate range of 20 to 100 milliseconds; therefore, the electrically operated valve 26 must be capable of responding mechanically open to close allowing to pass only the prescribed amount of energy from the storage vessel, with the balance energy for subsequent pulses to establish the predetermined pulsing pattern.

The programmer means 30 is a field adjustable unit that emits electrical signals in the 20 to 100 millisecond range to control the injector means. Each programmer means 30 has any number of channels of output, with the number practical for today's needs being from one to six channels. Along with the multiple output channels, the programmer has timer means to control the time and duration of the electrical signals. Thus, the programmer means 30 controls the number of electrical signal pulses per channel, the number of active channels, the total on and off time per channel, the time for subsequent channels to activate, the time to repeat the sequence of operations and the time between initiating complete programs.

The program selected dictates the exact sequence of energy bursts into the bulk material and is field-adjusted to the preferred sequence which causes the material to respond in the most sympathetic response to the action of the injector means 20. The selection of a program will dictate how the energy bursts are directed into the bulk material in any one of the following ways:

(1) A clockwise travelling energy wave;
(2) A counter-clockwise travelling energy wave;
(3) Alternate releases from opposite walls of a vessel;
(4) Alternate releases from two injectors at the same location;
(5) All injectors operation simultaneously; or
(6) Any combination of the above

The programmer means 30 is field-adjusted to locate a frequency to which the bulk material in the storage bin or vessel 40 will be naturally responsive, whether it be the preferred natural frequency of the bulk material, or some lesser or multiple of the natural frequency which causes bin activation. In some cases, the natural frequency of the material may be so different from the available pattern that the butrst pattern cannot be adjusted; therefore, the bulk material movement will respond solely to the instrument of the pulse pattern. Where possible the natural frequency of the bulk material is preferred since it will maximize energy burst effectiveness.

The selected program is field-adjusted to release only the number of energy bursts or pulses per injection which induces free flow. When the free flow is induced, the storage bin activator device 10 is then set in an at rest position until material flow interruption is detected. Then, the program is cycled again or it may be set to activate on a time interval basis determined by experience to prevent an arched, bridged or rathole situation before they can be established. With most materials, the storage bin activator device 10 is needed only to start the flow materials from an at rest condition since when material flows, there is a natural aeration. Thus, it becomes necessary to activate the storage bin activator device 10 only when the material flow is stopped or when removal of the bulk material is at a rate which permits restructuring of a blockage (arching, bridging, clinging or rathole condition) by the material itself. In the latter case, the storage bin activator device 10 can be programmed on a time interval to prevent the blockage before it can be established.

The common flow problems are those of arching (see Figure 1a); bridging (see Figure 1b); clinging (see Figure 1c) and rathole or piping (see Figure 1d). In each of these figures is also shown the desired positioning and arrangement of the storage bin activator devices 10 to eliminate these common flow problems. Also, while not shown in the drawings, a pulse pattern, as described herein, which is directed along pipes, recessed channels, seal areas and other areas where material retention or build-up is undesirable can effectively remove the disruptive materials from such areas.

The following general description of operation is given in order to provide a better understanding

of what is believed to be taking place during the multiple instantaneous energy burst release.

In the short instant (20 to 100 milliseconds) of the compressed gas burst, each burst or injection of compressed gas acts directly on the particles it contacts and causes motion thereof in line with the movement and expansion of air. Simultaneously, with the initial movement of the materials, there is aeration of the materials from the expansion of the compressed gas. The programmer means 30 are set so that before moving particles from the initial burst comes to rest, a second energy release of compressed gas is injected into the bulk material. Since the moving particles from the initial burst are still moving, and the activated area is at an elevated pressure, the second burst imparts a greater movement, disruption or aeration force because it is acting on or amplifying the initially moved particles. Each subsequent energy release is programmed to act on materials that are not at rest, but rather have kinetic energy in their movement, such that the subsequent energy releases, even those of lesser energy levels than previous bursts, are more effective than the previous bursts due to the amplification effect. The energy level of the particles in motion increases with each burst or pulse to a higher level, and this higher motion is transmitted to more and more particles with impact and aeration stimulation extended into the entire vessel. The energy bursts or pulses are released at a field-adjustable rate or frequency that is most responsive to the bulk material in order to achieve sonic stimulation as well. The multiple instantaneous energy releases of impact, aeration and sonic stimulation act, in concert with one another, directly on the material to immediately induce free flow thereof. When the proper program, location and number of storage bin activator devices 10 have been selected, an entire storage vessel can be totally activated to induce free flow in from less than one second to a few seconds. Disruptive materials in pipes, recessed channels, seal areas and other areas are also similarly removed within this time frame.

It will be apparent that the instantaneous injection of the above discussed forms of stimulation/activation energy (impact, aeration and sonic) which are concentrated in and on the materials can be adjusted to supply the precise amount of energy to achieve total stimulation through maximum efficiency. Maximum stimulation with minimum energy depends on the combination of the compressed gas pressure level, the frequence of the bursts or pulses, the pressure profile of the energy bursts, the location and number of injector means, and the field tuning of the programmer means.

Th material activation forms of impact, aeration and sonic stimulation are somewhat illustrated in Figures 1 and 2 of the drawings where a plurality of closely grouped concentric rings are depicted as the impact force with the aeration and sonic stimulation forces being represented by the graph-like profile illustrations.

From the foregoing, it will be appreciated that the storage bin activator device and method of the present invention quickly and efficiently restores free flow to bulk material in a storage vessel or r moves disruptive materials from other containment vessels. Further, with selection, control and adjustment of the components of the system maximum effectiveness can be achieved with minimum time and energy expended. The overall result is a device and method which far exceeds the operation and effectiveness of all other known prior art devices and methods.

Claims

1. A material activator device to restore the free flow of material or remove disruptive materials from a containment vessel, comprising means for introducing multiple instantaneous energy bursts of impact, aeration and sonic stimulation directly into the material to dislodge or induce free flow thereof from the containment vessel.

2. A material activator device according to Claim 1, wherein said means for introducing multiple instantaneous energy bursts of impact, aeration and sonic stimulation includes injector means for introducing a compressed gas at the desired frequency and programmer means to regulate the introduction of the multiple instantaneous energy bursts of compressed gas by the injector means as an impact force with the desired frequency.

3. A material activator device according to Claim 2, wherein the injector means comprises an electrically operated valve means controlled by said programmer means and compressed gas storage means controlled by said electrically operated valve means.

4. A material activator device according to Claim 3, wherein said both said electrically operated valve means and compressed gas storage means are mounted immediately adjacent to one another and to said containment vessel in order to maximize response time with minimum system losses.

5. A material activator device according to Claim 3 or 4, wherein said programmer means emits electrical signals in the millisecond range to the electrically operated valve means.

6. A material activator device according to Claim 5, wherein the millisecond range is approximately from 20 to 100 milliseconds.

7. A material activator device according to claim 5 or 6, wherein the programmer means has multiple channels of electrical signal output and timer means, and said programmer means controls the number of electrical signal pulses per channel, the number of active channels, the total on and off time per channel, the time for subsequent channels to activate, the time to repeat the sequence of operations and the time between initiating complete programs.

8. A material activator device according to claim 5 or 6, wherein there are a plurality of

selectively located injector means positioned about said containment vess l, and at least said one programmer means controls the direction, intensity and timing sequence of said injector means relative to one another.

9. A method of restoring free flow or removing disruptive materials from a containment vessel, comprising the steps of introducing multiple instantaneous energy bursts of impact, aeration and sonic stimulation acting directly into the material to dislodge or induce free flow thereof from the containment vessel.

10. A material activator device substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

11. A method of restoring free flow or removing disruptive materials from a containment vessel, substantially as hereinbefore described with reference to the accompanying drawings.

12. Any novel feature or combination of features herein described.

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